

SILURIAN POLYZOA FROM BENTHALL EDGE, SHROPSHIRE

By DAVID ELYSTAN OWEN

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SYNOPSIS

A small collection of Polyzoa from Wenlockian strata of Benthall Edge, Shropshire, contains seventeen species, four of which were described from American Silurian rocks and seven of which are new.

I. INTRODUCTION

WHEN Davidson was writing his great series of monographs on British Fossil Brachiopoda for the Palaeontographical Society he had some assistance from George Maw of Benthall Hall, south-west of Ironbridge. Maw was a keen amateur geologist and was wonderfully placed for collecting from the Wenlock series. The methods he employed to acquire a really representative fauna were a cross between modern wholesale collecting and factory labour of the Industrial Revolution and were charmingly described (Maw *in* Davidson & Maw 1881 : 100-101) with colourful details. Some twenty tons of shale from Wenlock and Ludlow beds from approximately forty localities were collected, crushed, washed and sieved, and women were employed at one shilling and sixpence a day to pick out the fossils. Further, the old quarries on Benthall Edge were picked over by hand. The brachiopods were all handed over to Davidson, who described the additions to his earlier species in a special supplement (1881).

The Polyzoa came into the hands of G. R. Vine of Sheffield. Vine had been interested in Polyzoa at least as early as 1877 when he started a series of papers on Carboniferous forms from Yorkshire, many of which were published in the Proceedings of the Yorkshire Geological and Polytechnic Society. Vine wrote to Maw and asked permission to examine the Polyzoa from the washings, and was sent approximately two and a half hundredweight of small fragments which he proceeded to work through with a hand lens. He described how he picked out upwards of two hundred thousand specimens of small corals, Polyzoa, Entomostraca, etc., and embarked on the description of the Polyzoa, publishing his first paper in the Quarterly Journal of the Geological Society in 1882. He described a number of species, a few of them new, and was very strong on the Ctenostomata and on certain of the simple Cyclostomata. It is clear, however, that he was very uncertain of the great mass of Trepostomata, of Ceramoporoid Cyclostomata and of Cryptostomata other than the reticulate forms. Such names as *Drymatopora problematica* Vine, *Polypora problematica* Vine and *Thamniscus problematica* Vine hint of his difficulties, and his last paragraph (1882 : 68) reads "I have endeavoured, in the above paper, to give as few microscopical details as possible, because these seemed to me to be rather out of place. I cannot, however, let the paper pass beyond my control without saying that every species recorded has been examined macroscopically and microscopically. The sections prepared have revealed many unexpected features that will help to throw some light at least upon the development of the Polyzoa generally, and upon the biological history of the Silurian Polyzoa in particular". In his list of species, *Monticulipora* sp., which he thought, with Nicholson (1879 : 253), was a coral, was noted (p. 47) as "very rich, but the whole wants working". Later (1886a : 228) he wrote "had I met someone who would have cooperated with me, the Actinozoa division, chiefly the Monticuliporidae of my list, would have been much fuller than it is".

The following year (1883) Vine read a second paper to the Geological Society of London, but this appears only in abstract. Thirty-nine genera of corals and Polyzoa were listed and two new species, *Leioclema granatus* Vine and *L. pulchellus* Vine, were described. Unfortunately the manuscript is not in the library of the Geological Society. After that, Vine returned to his native Yorkshire and his final two Silurian Polyzoa papers (1886 and 1886*a*) were in the Proceedings of the Yorkshire Geological and Polytechnic Society. In these again he described and listed species, but his emphasis was largely on Ctenostomata which he knew and understood well. He also wrote at length on the classification of the group both here and for the British Association as secretary of a Committee making a study of them (1881).

Thus, at a time when Ulrich was publishing papers on Ordovician, Silurian, Devonian and Carboniferous Polyzoa, superbly illustrated with lithographs showing the species in section, and Nicholson sectioning Monticuliporids, the opportunity of describing completely the Silurian polyzoan fauna from such a wealth of material was lost. Thirty years after his death, Vine's son handed over his geological collections to Sheffield Museum. All that is left there of the two hundred thousand specimens picked out are about two hundred mounts each containing one or more specimens, nearly half of which are corals. Amongst them are a very few sections too poor and thick to be of much use. In addition, there is a tray containing small boxes of unsorted material from the numbered localities and a further tray containing other unsorted material. Besides the Sheffield collection, there are a number of mounts with similar specimens and thick microscope sections in the collections of the British Museum (Nat. Hist.), the Geological Survey Museum and the Welsh National Museum at Cardiff. Throughout, many of the mounts often contain more than one species. In addition, there are three trays in the British Museum (Nat. Hist.) which, through the courtesy of Dr. H. Dighton Thomas, I have been able to examine. Two are not particularly rich, and their labels suggest that they contain mixed portions from several localities. The third, labelled Benthall Edge, contains a quantity of first-class material. It is from this tray that all the specimens described in this paper have been separated.

It was not until I had spent a considerable time isolating, sectioning and mounting these specimens that I found the Sheffield material (at the suggestion of Professor L. R. Moore). Having examined it carefully, I do not think any useful purpose would be served by including it in this review.

Throughout this paper I have followed the custom of the British Museum (Nat. Hist.) and referred to this group as Polyzoa. In common with many workers overseas I have previously used the name Bryozoa. I have, however, recently re-read Thompson (1830) and am quite satisfied that the name Polyzoa properly refers to these creatures and should be accepted on grounds of priority.

II. AGE OF THE MATERIAL

The material consists of some thousands of fragments mostly around a few millimetres in length and 0.5 to 3 mm. in diameter. It appears to be a portion from one sifting and the label "Benthall Edge" suggests that it is the washings from that

locality, north-east of Much Wenlock. There the massive Wenlock Limestone rests on the very fossiliferous Tickwood Beds, and it seems most likely that the washings were from those shales. The old quarries and exposures are heavily overgrown to-day, but similar material occurs at this level.

The Tickwood Beds are described (Whittard 1952 : 169) as being the uppermost members of the thick Wenlock Shale and to lie in the zone of *Cyrtograptus lundgreni*, and there is little doubt that this zone also includes at least the lowermost beds of the Wenlock Limestone. The probability, then, is that the Polyzoa described here are from beds of this age.

The species belong to the three orders Cyclostomata, Trepostomata and Cryptostomata, and the two typical Silurian genera *Leioclema* and *Eridotrypa* are both well represented. The deposit from which the material appears to have been collected is very similar in lithology to a number of levels in the Ludlovian, yet the polyzoan fauna is almost entirely different. The only three species common to both are *Fistulipora crassa* (Lonsdale), *Favositella interpuncta* (Quenstedt) and *Monotrypa flabellata* Owen. This suggests that the smaller Polyzoa may be of some use for zonal purposes over a limited area.

On the other hand, only four species—*Hallopora elegantula* (Hall), *Hallopora striata* (Hall), *Leioclema asperum* (Hall) and *Pachydictya crassa* (Hall)—appear to be common to this deposit and the highly fossiliferous Rochester Shales of New York State whose Polyzoa were described by Bassler (1906). I have looked in vain for more of the characteristic species from that deposit. In the same way I have looked for these British species in the Russian literature, particularly of Astrova (1959) and Nekhoroshev (1961), but have not found them.

III. METHOD OF SECTIONING

A very large number of the specimens for study were small, measuring only a few millimetres in length and perhaps one or two millimetres in diameter. In order to be sure of getting the proper sections correctly orientated, I cut such specimens into three parts using a small diamond cutting wheel mounted on a dental drilling apparatus. One portion was then mounted for reference, and the other two embedded in a proprietary brand of hard plaster of paris. It was then possible to grind away sufficient of each specimen to show the tangential and the vertical sections, to mount them on glass, and to complete the microscope slide. Besides allowing the right planes to be ground on the material, the plaster was of great value in holding together friable specimens which otherwise tended to break up before the section was sufficiently thin to show such features as the laminae in the walls.

IV. SYSTEMATIC DESCRIPTIONS

Order **CYCLOSTOMATA** Busk 1852

Family **DIASTOPORIDAE** Gregory 1899

Genus **MITOCLEMA** Ulrich 1882

Ulrich described this genus to include simple Polyzoa with slender ramose zoaria with more or less prominent apertures arranged in transverse series around the

branches or in an irregular spiral. He compared it with both *Spiropora* Lamouroux and *Entalophora* Lamouroux, but pointed out that those forms were Jurassic to Recent and that there were no known links with the Palaeozoic species, then described only from the Ordovician. He therefore felt that these last should be placed in a separate genus. Silurian forms are now known to be fairly common and links may yet be found in the younger Palaeozoic and the older Mesozoic beds. The family is an interesting one in the simplicity of its form and structure and the fact that it continues with little change from Ordovician to Recent times.

Mitoclema regularis (Vine) comb. nov.

Pl. I, figs. 1, 2.

1882 *Spiropora regularis* Vine : 55, text-figs. 4-6.

MATERIAL. PD 4233-39.

DESCRIPTION. The zoaria consist of slender cylindrical tubes with raised circular zooecial apertures on all sides forming an irregular spiral. Simple zooecia arise centrally and run parallel to the axis, finally curving out slightly to reach the surface at an angle of about 45 degrees. No diaphragms, mesopores, or acanthopores occur.

MEASUREMENTS.

Diameter of zoaria		1 mm.
Apertures raised up		0.2 mm.
Diameter of apertures		0.2 mm.
Number of apertures in 2 mm. longitudinally		1.5
Number of apertures in 2 mm. laterally		6

REMARKS. This beautiful little species is moderately common in the collection and is very characteristic. In worn specimens, as was noted by Vine, the outer zooecial wall below the aperture is often perforated, showing a single long cavity from the aperture or even an aperture and a hole beneath it. Vine placed the species in the Mesozoic genus *Spiropora*, which it closely resembles. Bassler (1952 : 381) introduced *Mitoclemella* to take the species of *Mitoclema* with zooecial apertures spiralling round the zoarium. Ulrich's original description of *Mitoclema* allowed for such species and I therefore retain this species in his genus.

Family CERAMOPORIDAE Ulrich 1882

Genus CERAMOPORA Hall 1851

Hall (1851 : 400) described this as incrusting or flattened hemispherical with cells arranged in alternating or imbricating series, the apertures arching or triangular with the apex above. Though he placed it among the corals, he noted that it was probably a polyzoan. Ulrich (1890 : 463, pl. 39, figs. 1-1b) chose as type species *C. imbricata* from the Rochester Shale at Lockport, New York, and he re-described it and figured its internal structure as shown by sections. He stated that the lower or basal portion of the zoarium was composed of a cellular or spongy tissue from which the zooecia grew out more or less obliquely. He further pointed out that the

intercellular space between the non-tabular zooecia was occupied by irregular flexuous rows of mesopores, the zooecia and tubes interconnecting by perforations in the walls. Lunaria were said to be small but well-marked.

Ceramopora sp.

Pl. 1, figs. 3, 4.

MATERIAL. PD 4240-42.

DESCRIPTION. Zoaria small and discoid. Zooecia occur as simple inverted cones and cylinders with thick granular walls. Mesopores are common, sometimes closed, with numerous curved diaphragms forming in places vesicular tissue which is much thicker at the base of the specimen. Apertures are large, nearly circular, with small lunaria, in contact or separated by polygonal mesopores. Acanthopores are wanting.

MEASUREMENTS.

Diameter of zoarium		5 mm.
Thickness of zoarium		2 mm.
Size of apertures		0.4-0.5 × 0.4-0.55 mm.
Width of lunaria		0.16-0.20 mm.
Size of mesopore apertures		closed to 0.2 × 0.2 mm.
Number of apertures in 2 mm.		4
Thickness of walls		0.04-0.15 mm.

REMARKS. This species is represented by a single specimen whose slightly hollowed upper surface is typical of the genus. The thick mass of vesicular tissue resolves itself into mesopores, most of which die out before reaching the surface. Though similar in zoarial shape to the species of the Niagara Limestone and Rochester Shales of New York State and to the Silurian forms from Gotland, it differs in having greater regularity of zooecial form and less looseness. As this is a single specimen whose preservation is not perfect, it is not here described as a new species.

Genus *FAVOSITELLA* Etheridge & Foord 1884

Favositella interpuncta (Quenstedt)

- 1878 *Favosites interpunctus* Quenstedt : 10, pl. 143, fig. 9.
 1884 *Favositella interpuncta* (Quenstedt) Etheridge & Foord : 473, pl. 16, figs. 1-1f.
 1911 *Favositella interpuncta* (Quenstedt) ; Bassler : 100, fig. 35.
 1962 *Favositella interpuncta* (Quenstedt) ; Owen : 197, pl. 28, figs. 1, 2.

MATERIAL. PD 4243-45.

REMARKS. A single, typical, small, encrusting specimen of this species occurs in the collection. It shows the uneven perforated walls with dark granular centres, the tabulated mesopores and even the enclosed "brown bodies" or "pearls" described by Oakley (1934). It is a relatively poor specimen. With regard to the description of both genus and species, I have nothing to add to my comments (1962 : 197).

Family **FISTULIPORIDAE** Ulrich 1882Genus **FISTULIPORA** McCoy 1849, emend. Nicholson & Foord 1885

The genus was first described by McCoy (1849 : 130) in the following words :—
 “ Corallum incrusting, composed of long, simple, cylindrical, thick-walled tubes, the mouths of which open as simple equal circular cells on the surface, and having transverse, funnel-shaped diaphragms at variable distances ; interval between the tubes occupied by a cellular network of small vesicular plates ”. Later, Nicholson & Foord (1885 : 500) re-described it more fully, noting that it was variously shaped, that the cylindrical zooecia had lunaria, that diaphragms were horizontal, that tabulate mesopores often coalesce to give rise to vesicular tissue, and that occasional acanthopores occur in the zooecial walls forming blunt spines at the surface. This was the first time that the terms “ mesopore ” and “ acanthopore ” were used and the lunules (lunaria) were also named. It should be remembered that Nicholson still considered the genus to belong to the corals. Acanthopores are not now considered to occur in the genus.

This amended description seems to sum up the genus fairly accurately though the number of species now described is so great that it may need further study.

Fistulipora crassa (Lonsdale)

Pl. 1, fig. 5 ; Pl. 2, figs. 1, 2.

1839 *Heteropora crassa* Lonsdale : 680, pl. 15, figs. 14–14a.1884 *Fistulipora crassa* (Lonsdale) Nicholson : 118, pl. 7, figs. 1–2a.1885 *Fistulipora crassa* (Lonsdale) ; Nicholson & Foord : 506, pl. 15, fig. 1.1962 *Fistulipora crassa* (Lonsdale) ; Owen : 197.

MATERIAL. PD 4246–67.

DESCRIPTION. Zoarium ramose or encrusting, in the latter case often covering other species of Polyzoa, and consequently difficult to distinguish macroscopically from the ramose form. Ramose examples are occasionally slightly flattened. Neither maculae nor monticules are seen and lunaria occur as complete rings, slightly raised around the apertures. Zooecia are simple, thin-walled tubes, in ramose forms running parallel and then curving gently outwards to reach the surface at right angles, and in encrusting forms arising from a basal epitheca at a low angle and curving gently to the surface, with occasional diaphragms. Mesopores occur as a vesicular mass, but in ramose forms are to be found in the exozone only. Apertures are circular to oval, completely ringed by lunarial tissue ; mesopore apertures are polygonal, often closed at the surface by calcareous tissue.

MEASUREMENTS.

Diameter of ramose zoaria	.	.	.	.	.	2–4 mm.
Thickness of encrusting zoaria	.	.	.	.	.	0.5–1.25 mm.
Size of apertures	.	.	.	0.15–0.2 mm.	×	0.1–0.15 mm.
Thickness of lunarial tissue	.	.	.	.	.	0.02–0.04 mm.
Size of mesopore apertures	.	0.08–0.12 mm.	×	0.1–0.16 mm.	.	
Number of apertures in 2 mm.	.	.	.	.	.	6–9

REMARKS. The ramose forms are common in the collection and the encrusting forms rather less so. The similarity in the exozone of the ramose forms and the entire encrusting forms is such that I have no hesitation in placing them in the same species. They are indistinguishable in tangential section and a complete incrustation of another ramose polyzoan makes it impossible to distinguish them without a vertical or transverse section. Furthermore, both forms are notable for the lunaria completely encircling the apertures, a fact noted by Nicholson (1884 : 118) when he re-described the species. Both have a thin cortex of calcareous tissue which often hides the mesopore apertures. Both Lonsdale and Nicholson had specimens from Benthall Edge, Lonsdale's figured specimen (1839, pl. 15, fig. 14) being 10 mm. in diameter and Nicholson's specimens being described as 2-12 mm. across. Nicholson & Foord (1885, pl. 15, fig. 1) figure a very large specimen. The ramose specimens described here vary from 2-4 mm. and, like those in Nicholson's description (1884 : 118), are slightly flattened.

Nicholson (1884 : 119) described *Fistulipora ludensis* as a small encrusting form otherwise very similar to *F. crassa*. It was said to differ in having spiniform tubules (acanthopores) and rather more mesopores, as well as in its zoarial form. I have not seen any specimens of this species and neither have I seen acanthopores in the genus. It seems possible that Nicholson mistook certain thickenings in the lunaria for acanthopores and that this species is the encrusting form of *F. crassa* (Lonsdale). *Fistulipora dobunica* (Nicholson & Foord 1885 : 511, pl. 17, figs. 3-36) was also described as an encrusting form from the Wenlock Limestone, but its well-marked maculae and its very tiny apertures (12 in 2 mm.) distinguish it. *Fistulipora lockportensis* Bassler is the only one of four species of *Fistulipora* described by Bassler (1906 : 23, pl. 7, figs. 1-3) from the Rochester Shale which is comparable. While the other three species have horseshoe-shaped lunaria, in that species they appear as a complete ring. *F. lockportensis* is, however, a large and massive form, the zoaria measuring as much as 10 cm. across and the apertures 4 to 2 mm.

Order **TREPOSTOMATA** Ulrich 1882

Family **BATOSTOMELLIDAE** Miller 1889

Genus **ERIDOTRYPA** Ulrich 1895

Ulrich introduced this genus to include certain species formerly described as *Batostomella*, which he proposed to restrict to the Carboniferous, and for a number of new species for which he could find no existing genus. He described it (1895 : 264) as ramose with slender branches. "Zoecia more or less oblique, with thick walls, the tubes intersected by diaphragms only. The latter may be wanting in the axial region, are in most cases absent for a short distance within the apertural edge, but are always present and closest together in the turn from the axial into the narrow peripheral region. Mesopores with close-set diaphragms, varying in number, sometimes abundant, at other times very few. Acanthopores small, never numerous, sometimes wanting". The most noticeable features of species in this genus to me are the short, thickened walls of the exozone and the mesopores, often closed in this

region. In many species the base is expanded or encrusting and the ramose portion rises from this. Where visible, the laminae show Leioclemid wall structure and possibly link *Eridotrypa* to *Leioclema*, which differs mainly in the great development of large acanthopores.

Eridotrypa cylindrica sp. nov.

Pl. 2, figs. 3, 4.

DIAGNOSIS. *Eridotrypa* with thin-walled zooecia without diaphragms in the endozone and with thick mass of laminated tissue forming exozone and showing Leioclemid wall structure.

MATERIAL. Holotype PD 4268-70 (specimen and sections).

Paratypes PD 4271-78.

DESCRIPTION. Zoarium cylindrical, ramose. Zooecia occur as long, thin-walled tubes in the endozone, bending sharply into the exozone where the walls thicken and straighten out to reach the surface at about 70°. Wall laminae curve distally in a marked figure U. Mesopores often closed, occur in exozone only. Diaphragms in mesopores and occasionally in zooecia in exozone. The laminae of the diaphragms show Leioclemid wall structure perfectly (cf. Boardman 1960 : 30, 31). Apertures rounded to oval or polygonal with rounded corners, ringed around with dark tissue. Mesopore apertures polygonal. Occasional small acanthopores, often difficult to tell in tangential section from a nearly closed mesopore.

MEASUREMENTS.

Diameter of zoaria	.	.	.	.	.	2-3 mm.	
Thickness of exozone	.	.	.	.	.	0.8-1.0 mm.	
Size of apertures	.	.	.	0.14-0.2 mm.	×	0.1-0.17 mm.	
Thickness of surrounding ring	.	.	.	.	.	0.02-0.05 mm.	
Size of mesopore apertures	very minute to 0.06					×	0.04 mm.
Diameter of acanthopores	.	.	.	.	.	0.02 mm.	
Number of apertures in 2 mm.	.	.	.	.	.	8	

REMARKS. This is fairly easily recognisable macroscopically in an unworn specimen for the apertures appear polygonal and the mesopores and small acanthopores are not visible. With the thick mass of laminated tissue in the exozone and Leioclemid wall structure, it differs from all other species in the collection, in which it is relatively common. The thick tissue in the exozone, the sturdy rings round the apertures, the closed mesopores and the presence of only very small acanthopores lead me to place this species in *Eridotrypa* though its wall structure would seem to ally it to *Leioclema*. In appearance it compares fairly closely with *E. similis* Bassler (1906 : 31, pl. 12, figs. 10-14; pl. 26, figs. 1, 2) but differs in being smaller with smaller apertures, no thin diaphragms and smaller acanthopores.

Eridotrypa cava sp. nov.

Pl. 2, figs. 5, 6.

DIAGNOSIS. *Eridotrypa* with massive walls and apertures sunk in hollows. In the endozone the zooecia are closely tabulate, in the exozone they are ringed with dark tissue which shows up in tangential section.

MATERIAL. Holotype PD 4285.

Paratypes PD 4279-84 and PD 4286-88.

DESCRIPTION. Zoarium ramose. Zooecia arise centrally, run parallel and then turn sharply into exozone to reach the surface at or near a right angle. Walls in endozone thick and diaphragms numerous at about half tube-width intervals. In exozone, walls greatly thickened, integrate, with laminae which arise parallel to the inner edge of the wall and curve distally in a broad U-shape, though the centre is marked by an uneven black line. Only a few diaphragms enter the exozone. Small mesopores arise in the exozone and acanthopores are also visible in this region. Apertures oval and often partly closed by the thickness of the walls. The dark rings around them, in which lie the acanthopores, give them the appearance of lying in hollows, and in the solid specimen they are seen to do this. Mesopore apertures are often partially or even completely closed.

MEASUREMENTS.

Diameter of zoaria		1.5-2.5 mm.
Thickness of exozone		0.4-0.8 mm.
Size of apertures		0.1-0.3 mm. $\times$ 0.05-0.2 mm.
Size of mesopore apertures		from closed to 0.08 $\times$ 0.06 mm.
Diameter of acanthopores		0.02-0.04 mm.
Number of apertures in 2 mm.		6
Thickness of wall between two apertures		0.06-0.2 mm.

REMARKS. This is a common species and is easy to recognise in the unworn specimen through the massive walls and the apertures resting in hollows. Microscopically it is equally characteristic both in tangential and vertical sections, and differs in tabulation in the endozone and in massiveness in the exozone both from other species of *Eridotrypa* and from other forms in the deposit.

Eridotrypa sp.

Pl. 3, figs. 1, 2.

MATERIAL. PD 4289-95.

DESCRIPTION. Zoarium encrusting, thin, but occasionally thickening. Zooecia arise from a basal epitheca. In thin portions the endozone is very short and the fairly thick walls thicken rapidly into the exozone, which consists of a mass of thick calcareous tissue with threadlike hollow acanthopores running through. In the expanded portion the thin zooecial walls arise at a relatively low angle from the basal epitheca but quickly turn up towards the surface. They remain thin until they expand into the calcareous exozone. Diaphragms few. No mesopores. The polygonal apertures are surrounded by thick walls containing numerous small acanthopores.

MEASUREMENTS.

Thickness of zoaria in thin encrustations	0.2-0.3 mm.
Thickness of zoaria in expansion	2 mm.
Breadth of expanded portion	1.5 mm.
Thickness of exozone	0.1-0.4 mm.
Size of aperture	0.14-0.18 mm. $\times$ 0.1-0.16 mm.
Number of apertures in 2 mm.	10-12

REMARKS. This species is represented in the deposit by three specimens, two encrusting fragments of crinoid stem and the third encrusting a small coral. In PD 4293 there is a considerable expansion on one side, and the species is similar to *Eridotrypa umbonensis* Owen, differing from it in its lack of mesopores and less even shape of the apertures. The material is not sufficiently complete and well preserved to allow a new species to be based on it.

Family **STENOPORIDAE** Waagen & Wentzel 1886Genus **LEIOCLEMA** Ulrich 1882

Ulrich described this genus to include forms with encrusting, lamellar, subglobose or ramose zoaria, with zooecia whose apertures often become petaloid by the encroachment of large acanthopores in the walls, and with abundant mesopores which may even take on the vesicular appearance typical of *Fistuliporids*. Boardman (1960 : 30) described a typical *Leioclema* wall structure of diaphragm-wall units which can often be traced across two or three adjacent mesopores. In Silurian forms, I have not always found this wall structure though it shows clearly in some. This may be due in part to imperfect preservation. The other features described by Ulrich seem to me to distinguish it from associated genera.

Leioclema densiporum sp. nov.

Pl. 3, figs. 3, 4.

DIAGNOSIS. Ramose *Leioclema* with polygonal mesopores and many acanthopores surrounding and indenting each aperture.

MATERIAL. Holotype PD 4302-04 (specimen and sections).

Paratypes PD 4299-301 and PD 4305-08.

DESCRIPTION. Zoarium ramose, usually slender. Zooecia thick-walled throughout, arise centrally and curve gently to reach the surface at or near a right angle. Numerous mesopores and acanthopores develop in the exozone. Diaphragms few. Wall structure fairly clear, showing few laminae, with the typical *Leioclema* wall not visible. Apertures oval, indented by the many moderate sized acanthopores, and separated by polygonal mesopores.

MEASUREMENTS.

Diameter of zoaria		1.5-2.5 mm.
Thickness of exozone		0.3-0.6 mm.
Size of apertures	 0.14-0.18 mm. $\times$ 0.10-0.12 mm.	
Size of mesopore apertures	 0.08-0.16 mm. $\times$ 0.02-0.06 mm.	
Diameter of acanthopores		0.01-0.03 mm.
Number of zooecia in 2 mm.		8
Thickness of zooecial wall at surface		0.02 mm.
Number of acanthopores around aperture		8-12

REMARKS. The five specimens in the collection all show the same features quite clearly. In the unworn figured holotype the indented apertures, spines marking acanthopores, and polygonal mesopores are all clearly visible. I hesitate to leave this species in *Leioclema* as it does not show the typical Leioclemid wall and diaphragm structure, though this is not unusual in other Silurian species. It is, however, very typical of the genus as described originally by Ulrich (1882). It is not unlike the description of *L. multiporum* Bassler though that species is encrusting. Bassler (1906: 34) notes, however, that all of a small lot collected in Rochester, N. Y., differed from the usual method of growth and formed dwarfed branches. It differs, however, mainly in having larger zooecia and fewer mesopores.

Leioclema asperum (Hall)

Pl. 3, figs. 5, 6.

1852 *Callopora aspera* Hall : 147, pl. 40.1890 *Leioclema asperum* (Hall) Ulrich : 425.1906 *Lioclema* [sic] *asperum* (Hall) ; Bassler : 32, pl. 11, figs. 1-3 ; pl. 24, figs. 14-16.

MATERIAL. PD 4309-11.

DESCRIPTION. Zoarium small, encrusting or massive. Zooecia simple tubes arising from an epitheca and running directly to the surface with relatively few diaphragms. Numerous tabulate mesopores with diaphragms approximately tube-width apart. Large hollow acanthopores extend the whole depth. Once more it is difficult to comment on the wall structure which is more granular than laminar. Apertures circular or oval, deeply indented by the few very large acanthopores. Mesopores oval or polygonal with well rounded corners.

MEASUREMENTS.

Diameter of figured specimen		2.5 mm.
Depth		1.25 mm.
Size of apertures	 0.15-0.2 mm. $\times$ 0.12-0.15 mm.	
Size of mesopore apertures	 0.07-0.1 mm. $\times$ 0.04 $\times$ 0.07 mm.	
Diameter of acanthopores		0.05-0.1 mm.
Number of apertures in 2 mm.		8-9
Number of acanthopores to each aperture		2-4
Thickness of zooecial wall at surface		0.02 mm.

REMARKS. This single specimen fits in very closely with Bassler's description (1906) and with specimens identified by him in the British Museum (Nat. Hist.) collections. It is distinguished from other forms of *Leioclema* in the deposit by its encrusting habit and its particularly large acanthopores which show up clearly in vertical as well as tangential sections.

Leioclema ramosum sp. nov.

Pl. 3, figs 7, 8.

DIAGNOSIS. Ramose *Leioclema* with thick walls in endozone and Leioclemid wall structure clearly marked in exozone. Acanthopores one to three per zooecial aperture.

MATERIAL. Holotype PD 4315-17 (specimen and sections).

Paratype PD 4312-14.

DESCRIPTION. Zoarium ramose. Zooecia arise centrally and curve gently out to reach the surface at or even beyond a right angle. Walls fairly thick throughout, but thickening markedly in exozone in which both mesopores and acanthopores occur. The wall is typically Leioclemid (Boardman 1960 : 30-31), wall-diaphragm units extending across many mesopores, the diaphragms occurring approximately a tube-width apart. Diaphragms also occur in the exozone in the zooecia. Mesopores fairly numerous, sometimes closed. Apertures oval or polygonal with rounded corners, mesopore apertures similar but smaller. Acanthopores relatively few and very large, often indenting the side of the zooecial aperture, one, two, or at most three to an aperture.

MEASUREMENTS.

Diameter of zoaria	.	.	.	.	.	2-2.5 mm.
Thickness of exozone	.	.	.	.	.	0.75-1 mm.
Size of apertures	.	.	0.12-0.16 mm.	×	0.08-0.12 mm.	
Size of mesopore apertures	.	.	Closed to 0.1	×	0.05 mm.	
Diameter of acanthopores	.	.	.	.	.	0.05-0.09 mm.
Number of apertures in 2 mm.	.	.	.	.	.	10
Thickness of walls	.	.	.	.	.	Up to 0.1 mm.

REMARKS. This is one of the few Silurian species of *Leioclema* which shows the wall structure clearly. It is not very different from *Lioclema* [sic] *ramulosum* Bassler (1906 : 35, pl. 11, figs. 11-13 ; pl. 25, figs. 9, 10) but differs in having relatively thick walls in the endozone and in having diaphragms. It differs from other species of *Leioclema* in the collection in its beautifully formed Leioclemid wall structure, but otherwise compares closely particularly in tangential sections.

Family CONSTELLARIIDAE Ulrich 1890

Genus *NICHOLSONELLA* Ulrich 1890

This genus was introduced by Ulrich (1890 : 374, 421) to include four or five Ordovician species, one of which had already been described by him as a species of

Heterotrypa Nicholson. The type species, *N. ponderosa* Ulrich, is very large, and all were described as having irregularly intertwining flattened branches or fronds. Zooecia were said to be tubular with circular apertures and a faint granular peristome. The walls were thin and traversed longitudinally by minute tubuli. The numerous angular mesopores were said to isolate the zooecia, but acanthopores were not mentioned. With age the interzooecial spaces were said to become filled with a perforated calcareous deposit. The figures showed the shadowy nature of the walls. Bassler (1906 : 38, 39, pl. 14, figs. 10-14 ; pl. 24, figs. 1, 2) added two Silurian species from the Rochester Shale of New York State. Both were explanate expansions and were very similar to Ulrich's Ordovician forms with the same shadowy walls and the calcareous deposit filling interzooecial spaces, but both had many large granular acanthopores. I have examined sections of *Nicholsonella florida* (Hall) in the British Museum (Nat. Hist.) collections named by Bassler, and feel that the genus would be more properly placed in the Cyclostomata near *Fistulipora*. In describing *F. umbrosa* Owen (1960 : 69, 70, pl. 16, figs. 1, 2) I was struck by the similarity of the shadowy walls to those of species of *Nicholsonella*, but felt that it was otherwise a very typical *Fistuliporid*. Such walls occur frequently in Ceramoporoids and less often if at all in the more typical *Trepostomata*.

Nicholsonella parva sp. nov.

Pl. 4, figs. 1, 2.

DIAGNOSIS. Small *Nicholsonella* with numerous large acanthopores which only slightly indent the apertures.

MATERIAL. Holotype. PD 4321.

Paratypes PD 4318-20.

DESCRIPTION. Zoaria hemispherical or encrusting, small, with spiny projections marking the position of stout acanthopores. Zooecia short, straight or curved with moderately thick granular walls and no diaphragms. Mesopores common, tabulated, diaphragms approximately a tube-width apart. Acanthopores large with hollow centres and granular walls about three to a zooecium. Apertures circular or oval, touching or separated by polygonal mesopores, frequently slightly indented by acanthopores.

MEASUREMENTS.

Breadth of hemispherical zoarium		4-5 mm.
Height of hemispherical zoarium		3 mm.
Size of apertures		0.3-0.4 mm. diameter.
Size of mesopore apertures		0.05-0.08 mm. $\times$ 0.06-0.1 mm.
Diameter of acanthopores		0.05-0.08 mm.
Number of zooecia in 2 mm.		4-5

REMARKS. The shadowy nature of the walls and the simple tubular zooecia place this species clearly in *Nicholsonella*. Only three specimens occur in this collection, two hemispheres and one thin incrustation. The zooecia are slightly smaller than those of *N. florida* (Hall 1852 : 146, pl. 40, figs. 2a-f), the mesopores less

vesicular, the acanthopores fewer and relatively larger, and the apertures less flori-form, but otherwise this species is very like Bassler's description (1906 : 38, pl. 14, figs. 10-11 ; pl. 24, figs. 1, 2) of Hall's species, which has, however, large explanate zoaria. It also differs from *N. ringuebergi* Bassler (1906 : 39, pl. 14, figs. 12, 13) in having larger zooecia whose apertures are not so deeply indented as to be petaloid as is the case in that species.

Family HALLOPORIDAE Bassler 1911

Genus HALLOPORA Bassler 1911

This was introduced as a new name for *Callopora* Hall (*non* Gray 1848 : 109, 146). Hall described *Callopora* (1851 : 400) as "ramose or incrusting with a columnar structure ; cells tubular with the apertures circular or petaloid, not contiguous, and having the intermediate spaces occupied by angular cell-like openings which are transversely septate ; tubular cells rarely septate". The type species, *C. elegantula* Hall, was well figured in 1852 (pl. 40, fig. 1-1*n*), and it shows clearly the characters of the genus. Bassler added, in his renaming (1911 : 325), that zoaria of *Hallopora* were almost always solid, ramose and bushy, and in the perfect state the apertures were closed by perforated ornamental covers, which, as growth proceeded, formed the diaphragms of succeeding layers.

Hallopora elegantula (Hall)

Pl. 4, figs. 3, 4.

1852 *Callopora elegantula* Hall : 144, pl. 40, figs. 1-1*n*.

1882 *Callopora elegantula* Hall ; Ulrich : 250, pl. 11, figs. 6-6*b*.

1884 *Callopora nana* Nicholson : 120, pl. 7, figs. 4-4*b*.

1906 *Callopora elegantula* Hall ; Bassler : 41, pl. 17, figs. 11-15 ; pl. 26, fig. 12.

1911 *Hallopora elegantula* (Hall) ; Bassler : 334, text-fig. 210.

MATERIAL. PD 4322-33.

DESCRIPTION. Zoaria ramose often relatively stout. Zooecia arise from centre and curve gently out to reach the surface at right angles. Diaphragms numerous and closely spaced in endozone, becoming fewer in exozone where numerous closely tabulated mesopores occur. Zooecial wall integrate in the inner part of the exozone, with laminae running a short distance nearly parallel to the wall and forming a V distally, which shows up as a black line in section, but the V and the black line become much less marked near the surface. Mesopore diaphragms show Leiocleimid wall structure, the laminae of one diaphragm running into the wall distally and curving back from a blunt V to run into the diaphragm of the next mesopore. No acanthopores. Apertures circular or oval, separated by polygonal mesopores.

MEASUREMENTS.

Diameter of zoaria	.	.	.	.	.	.	2-5 mm.
Size of apertures	.	.	.	0.3-0.4 mm.	×	0.25-0.3 mm.	
Size of mesopore apertures	.	.	.	0.1-0.2 mm.	×	0.05-0.2 mm.	
Number of apertures in 2 mm.	.	.	.	.	.	.	5

REMARKS. This is the commonest polyzoan in the collection and one of the commonest in the Wenlockian. It is easy to distinguish macroscopically by its relatively stout form and the circular apertures clearly separated by mesopores. Microscopically in all sections it is quite distinctive. It tallies exactly with Hall's description and figures and with specimens from the U.S.A. named by Bassler. It also compares with Vine's sections of *Callopora nana* Nicholson. In his original description of *C. nana*, Nicholson mentioned *C. elegantula* Hall but did not compare it with that species, even though he compared it with two American Ordovician species. The description, figures and the specimen so named in the British Museum (Nat. Hist.) collections are so like *C. elegantula* Hall that I have no doubt they are conspecific and that *C. nana* Nicholson is a junior synonym of *C. elegantula* Hall. Nicholson made the point in his species that both zooecia and mesopore apertures are elongated along the long axis of the zoarium, and I note this to occur occasionally but not generally. He described (1884 : 122, pl. 7, figs. 5-5b) *C. fletcheri* (Edwards & Haime) (1885 : 267, pl. 62, figs 3, 3a) as having circular apertures, and figured several mesopores adjoining one another, but he also noted the great thickening of the wall in the exozone which distinguishes it completely from this species. [The possible synonymy of *C. fletcheri* with *Hallopora ramulosa* (Phillips) has been discussed by Stubblefield (1938 : 30).]

Hallopora striata (Hall) comb. nov.

Pl. 4, figs. 5, 6.

1852 *Trematopora striata* Hall : 153, pl. 40, figs. 7a-d.

1906 *Eridotrypa striata* (Hall) Bassler : 32, pl. 12, figs. 4-6 ; pl. 24, figs. 3-6 ; pl. 25, fig. 14.

MATERIAL. PD 4296-98.

DESCRIPTION. Zoarium cylindrical, branching. Zooecia arise centrally and curve gently to reach the surface at or near a right angle. Walls integrate, fairly thick throughout, but thickening markedly in the exozone where the laminae are relatively straight, V-ing distally to form a central dark line. Mesopores common, sometimes closed. Diaphragms occur regularly throughout the length of the zooecia at intervals of a half to one tube-width, though they are less frequent at the surface, and in mesopores at approximately the same intervals. The laminae in the thick diaphragms show that the diaphragms form a unit with the wall after the manner of the Atachtotoechids (Boardman 1960 : 32), though the unit does not appear to continue into the neighbouring zooecium in the same way. Apertures oval. Acanthopores wanting.

MEASUREMENTS.

Diameter of zoaria	.	.	.	.	.	.	2-2.3 mm.
Size of apertures	.	.	.	.	.	0.3-0.4 mm. × 0.2-0.25 mm.	
Size of mesopore apertures	.	.	.	.	.	0.06 mm. × 0.04 mm.	
Number of apertures in 2 mm.	.	.	.	.	.	.	4-5

REMARKS. This small species came to light in sectioning numerous specimens of other species indistinguishable macroscopically. The integrate walls, tabulate zooecia and lack of acanthopores are typical of *Hallopora* Bassler. I compared it with sections in the British Museum (Nat. Hist) from Lockport, New York, labelled by Bassler *Eridotrypa striata* (Hall), and found it to be identical. Bassler's tangential section shows dark dots which he clearly took to be acanthopores though I am by no means certain that this is their real identity. The three specimens in the collection do not permit of sufficient examination for re-description of the species, but I consider that they, and Bassler's specimens mentioned above, belong to *Hallopora* Bassler and not *Eridotrypa* Ulrich.

Family **AMPLEXOPORIDAE** Miller 1889

Genus **MONOTRYPELLA** Ulrich 1882

Ulrich introduced this genus to include species very like those belonging to the ramose genus *Amplexopora* Ulrich but differing in the absence of acanthopores and in the presence in some species of what he described as closely tabulated interspaces that simulated mesopores. In his figures these appear to be typical mesopores.

It is the presence of numerous acanthopores that is the greatest difference between *Amplexopora* Ulrich and *Monotrypa* Nicholson, for both genera are always without mesopores. There seems to be little difference between species of *Monotrypella* without mesopores (or tabulated interspaces), and *Monotrypa*, though the latter was founded on a large massive "coral" and the former on a small ramose "polyzoan".

Monotrypella benthallensis sp. nov.

Pl. 5, figs. 1, 2.

DIAGNOSIS. *Monotrypella* with polygonal zooecial apertures of two sizes and Atactotoechid wall structure.

MATERIAL. Holotype PD 4334-36 (specimen and sections).

Paratype PD 4337.

DESCRIPTION. Zoaria ramose with groups of slightly larger zooecia but no true monticules. Zooecia run parallel for some distance and then curve gently out, finally making an angle or elbow to reach the surface at right angles. Zooecial walls thin in endozone, with diaphragms few or wanting, but thickening in exozone with a number of diaphragms mostly thin but a few rather thicker. Wall structure integrate, Atactotoechid (Boardman 1960 : 32), with laminae making a small angle with the walls and forming a V distally which shows as a dark line. Diaphragms continue forward into the wall but are easily lost in its structure. Mesopores and acanthopores wanting. Apertures polygonal, and integrate structure observable in thin black line which separates them.

MEASUREMENTS.

Diameter of zoaria		2-3 mm.
Thickness of exozone		0.2-0.6 mm.
Size of larger apertures		0.4-0.5 mm. $\times$ 0.2-0.25 mm.
Size of smaller apertures		0.2-0.25 mm. $\times$ 0.15 mm.
Number of larger apertures in 2 mm.		7
Number of smaller apertures in 2 mm.		9
Maximum thickness of zooecial wall in exozone		0.06-0.1 mm.

REMARKS. The exozone may be very short and the wall structure is then less easy to determine. The species is represented by four specimens and is easy to recognize macroscopically by the polygonal shapes of the zooecia with their larger groups, and by the lack of mesopores, and microscopically by the sharp angle which the zooecia make in the exozone. The vertical sections are very similar to those of *Eridotrypa echinata* Hall sp. (1879 : 112, pl. 11, figs. 1-5) named by Bassler in the British Museum (Nat. Hist.) collections, but the tangential sections of that species appear to show numerous very small acanthopores which are not present here. Furthermore, I do not believe this species belongs to the genus *Eridotrypa*. Although the wall structure appears to be Atactotoechid there are many differences between this and species of that genus. Absence of cystiphragms and of intermittent thickening of walls show that it is no near relative of *Atactotoechus*. The integrate wall structure and absence of mesopores suggest the Amplexoporidae, and the lack of acanthopores, the genus *Monotrypella*. I place it in this genus and not in *Monotrypa* Nicholson as it is a small ramose polyzoan and differs in form from typical Silurian species of *Monotrypa*.

Genus **MONOTRYPA** Nicholson 1879

This genus was first separated from *Monticulipora* by Nicholson (1879) and the subject was further elaborated in 1881. The essential features were the absence of mesopores, though the presence of larger and smaller zooecia, the former often collected in monticules, was noted. Acanthopores were absent except in *M. discoidea* (James) which was later removed from the genus. The walls were said to be thin, seemingly structureless, and apparently amalgamated to one another in some species, but in others were considerably thickened. In either case they were said to preserve the original lines of demarcation separating each zooecium. Diaphragms were entire, uniformly distributed, sometimes few or wanting.

This has since proved to be a very easily recognizable genus and many species have been described. Crenulate walls have proved a feature in a number. Where the walls are thick, their integrate nature and the black line formed by the V-ing of the wall laminae are clearly observable in both tangential and vertical sections.

Monotrypa flabellata Owen

Pl. 6, figs. 1, 2.

1960 *Monotrypa flabellata* Owen : 72, pl. 16, figs. 10-11 ; text-fig. 6.

1962 *Monotrypa flabellata* Owen ; Owen : 109, pl. 32, figs. 1, 2.

MATERIAL. PD 4338-47.

DESCRIPTION. Zoarium small, encrusting or hemispherical, with groups of larger zooecia showing on surface. Zooecia arise from the epitheca and are simple tubes with crenulate walls and numerous simple diaphragms. The walls are markedly integrate, with laminae arising from the inner sides at a low angle and running distally to form a V which shows up as a black line through the length of the wall. Apertures polygonal with the dark line of laminae clearly visible. No mesopores, though occasional, smaller zooecia are seen in sections. No acanthopores.

MEASUREMENTS.

Breadth of zoaria		up to 7 mm.
Thickness of zoaria		up to 2 mm.
Size of aperture of larger zooecia		0.5 mm. $\times$ 0.3 mm.
Size of aperture of normal zooecia		0.3 mm. $\times$ 0.2 mm.
Number of larger zooecia in 2 mm.		5-6
Number of normal zooecia in 2 mm.		7
Thickness of zooecial walls		0.2-0.3 mm.

REMARKS. I place the specimens of *Monotrypa* in the collections in this Ludlovian species though there are certain slight differences. The occasional groups of larger zooecia have not been observed in Ludlovian forms and the walls are, if anything, even stouter. There are rather more diaphragms, though diaphragms are occasionally numerous in Ludlovian specimens. The zoaria, too, are all smaller, though zoaria of other species in the deposit are also small. The thick wrinkled walls with the dark central line marked by the V-ing of wall laminae are so similar in these and the typical Ludlow forms as to make me consider them conspecific.

Order **CRYPTOSTOMATA** Vine 1883

Family **RHABDOMESIDAE** Vine 1883

Genus **RHOMBOPORA** Meek 1872

The genus was introduced for the Carboniferous species, *R. lepidodendroides* Meek, to include forms with slender, ramose, solid zoaria, and zooecia with vestibules within a very thick outer wall, numerous acanthopores and no mesopores. Ulrich in several papers (1890 *et alia*) described many species in this easily recognizable genus. Some had hemisepta serving to demarcate the vestibules. Moore (1929 : 134) discussed the genus, and drew attention to the fact that the type species had no hemisepta, and also that many forms described from older strata had hemisepta. Bassler (1953 : G. 134) noted "no hemisepta", but it seems that this is not a diagnostic generic feature.

Rhombopora mawi sp. nov.

Pl. 5, figs. 3-5.

DIAGNOSIS. *Rhombopora* with hemisepta and mesopores, sometimes closed, with thick diaphragms.

MATERIAL. Holotype PD 4350-52 (specimen and sections).

Paratypes PD 4348-49 and PD 4353-67.

DESCRIPTION. Zoaria ramose, some extremely slender and fragile and others rather stouter and stronger. Zooecia thin-walled tubes in endozone curving slightly from the axis and then turning more or less sharply to reach the surface at or near a right angle. The exozone is very thick and solid in the stouter specimens but thinner in the slim ones, and there are intermediate examples and even some with the exozone thicker on one side than the other. Well-marked vestibules particularly in stouter forms are completed with superior hemisepta and occasionally inferior hemisepta. Wall laminae make a low angle with the wall and curve distally into a U-shape. Occasional thin diaphragms occur. Mesopores are numerous in exozone, sometimes closed, containing many thick diaphragms whose laminae run up into the wall laminae after the manner of *Leioclemids*. Apertures are circular or oval, surrounded by a well-marked ring. Large hollow acanthopores are very numerous, particularly in the stouter forms, occurring in the thick calcareous tissue between the apertures, sometimes breaking the ring but never cutting into the aperture. Macroscopically the positions of the closed mesopores are marked by small depressions.

MEASUREMENTS.

Diameter of zoaria		1.8-2.5 mm.
Thickness of exozone		0.2-0.7 mm.
Diameter of endozone		0.8-1.2 mm.
Size of aperture	 0.08-0.12 mm. ×	0.05-0.1 mm.
Thickness of surrounding ring		0.02 mm.
Number of apertures in 2 mm.		9-11
Number of acanthopores surrounding apertures		5-10
Diameter of acanthopores		0.01-0.03 mm.

REMARKS. This is the second most common species in the collection. It is easy to distinguish macroscopically in unworn specimens, and is very distinctive microscopically where its thick cortex and deep vestibules distinguish it from other species. It is typically *Rhabdomesid* and I place it in the genus *Rhombopora* although it has well-developed hemisepta. The tabulated mesopores are another feature not normally associated with the genus. Perhaps a new genus should be introduced to take such species of *Rhombopora* with hemisepta and occasionally with mesopores. Such forms are common in both Silurian and Carboniferous rocks of England.

Family RHINIDICTYIDAE Ulrich 1895

Genus *PACHYDICTYA* Ulrich 1882, emend Ross 1961

In the emended genus Ross (1961 : 338) emphasized the salient features, including the microstructure of the walls. There is nothing to add to her description.

Pachydictya crassa (Hall)

Pl. 5, figs. 6-8.

1852 *Stictopora crassa* Hall : 45, pl. 18, figs. 4a-c.1893 *Pachydictya crassa* (Hall) Ulrich : 147.1906 *Pachydictya crassa* (Hall) ; Bassler : 57, pl. 18, figs. 11-12 ; pl. 21, figs. 14-16.

MATERIAL. PD 4368-76.

DESCRIPTION. Zoaria bifoliate, branching, with apertures in longitudinal rows on both sides. Very occasionally triangular in cross-section. Narrow strip along edges of ribbons without apertures. Occasional large zooecia stand out raised up on surface having the appearance of small volcanoes with central craters surrounded by side craters.

Zooecia arise on both sides of the mesotheca, which is pierced by numerous tubuli, and make an angle of about 60° with it, quickly becoming normal to the surface. The walls consist of a central laminate portion between the zooecia which contains the tabulate interspaces typical of the genus, and numerous acanthopores, and a clearer portion adjoining the zooecia. The larger zooecia have diaphragms. Apertures are oval and surrounded by dark rings and the spaces between them contain numerous small acanthopores. Mesopores wanting.

MEASUREMENTS.

Breadth of zoaria		4-5 mm.
Thickness of zoaria		1-1.5 mm.
Thickness of zoaria at an enlarged zooecium		2-2.25 mm.
Breadth of outer strip		0.5-0.7 mm.
Number of rows of zooecia		commonly 7
Size of aperture	 0.25-0.4 mm. $\times$	0.1-0.14 mm.
Longitudinal interspace		0.2-0.3 mm.
Lateral interspace		0.3-0.35 mm.
Number of apertures in 2 mm. longitudinally		4
Number of apertures in 2 mm. laterally		5

REMARKS. This is a common species and is easy to pick out macroscopically. It is notable for the occasional, enlarged zooecia which are, however, similar in section to those of normal size. It appears to be similar both to Hall's figures of *Stictopora crassa* (1852) and to Bassler's figures and descriptions of *Pachydictya crassa* (1906), though there is no sign of a linear ridge separating the zooecial rows. It differs from the Llandoveryan-Wenlockian *P. holmi* Hennig (1905 : 25, text-figs. 22-32, pl. 1, fig. 4) in having smaller apertures and less thickness, and in the zooecia having few diaphragms. Like that species the zoarium is very occasionally triangular in section. It differs from the Llandoveryan *P. dichotoma* Nekhoroshev (1961 : 156, pl. 34, figs. 2, 3) in having fewer rows of apertures to a branch. Nekhoroshev noted this as the main difference between his species and *P. crassa* (Hall), and stated that later forms show a reduction in the number of rows.

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